Glasgow Naturalist 2002. Volume 24. Part 1. Pages 51-58.

THE SCOTTISH LYNX: IS REINTRODUCTION A POSSIBILITY?

Katie McDonald

Division of Environmental and Evolutionary Biology, Institute of Biomedical and Life Sciences, Graham Kerr Building, University of Glasgow. G12 8QQ.

INTRODUCTION

The reintroduction of a species must fulfil two criteria to be viable. First it must be feasible from the point of view of all involved – the subject (the species to be returned), the host (the ecosystems into which the subject is to be introduced) and the activators (the conservation body undertaking the reintroduction). Second it must be of benefit to the subject species and/or the host ecosystem. The aim of this review is to discuss the extent to which the reintroduction of the Eurasian lynx to Scotland fulfils these criteria, and thus to consider whether, despite the length of its absence, the lynx has a potential role as *the* large carnivore of Britain. Before doing this it is necessary to summarise the natural history of lynx and the circumstances under which the species lived in, and was lost from, the UK.

THE BACKGROUND

Under Article 11 (2) of the European Union's Convention of European Wildlife and Natural Habitats, contracted parties, of which the British Government is one, should "encourage reintroduction of native species…when this would contribute to the conservation of an endangered species", conditional on a preliminary study to establish the likelihood of the reintroduction being "effective and acceptable." (Anon, 1979). Parties are next instructed to "strictly control the introduction of non native species." In neither the document nor its appendices is a definition of a native species given. What kind of criteria are being used to decide? It is clear from the quote above that contemporary residence is not a prerequisite, but is it a sufficient determinant?

Scottish Wildlife Trust (SWT), a major independent conservation organisation in Scotland, advocates complying with these recommendations. SWT does provide definitions of introduction and reintroduction. It is opposed to introduction, which it defines as "the intentional or accidental dispersal by human agency of a living organism outside its historically known native range". It is however cautiously in favour of reintroduction, which it specifies as - "The intentional movement of an organism into part of its native range from which it has disappeared or become extirpated in historic times as the result of human activities or natural catastrophes," (SWT, 2000).

These statements imply that residence in a country does not make a species native: a country's native animals are those which colonised independently. What is also apparent is that the return of presently absent native animals is desirable but non native arrivals are not welcome.

The modern flora and fauna of the Northern Hemisphere could only begin to establish themselves when temperatures climbed out of the lows of the most recent Ice Age, that is, no earlier than 12,000 - 10,000 bp. The final stadial (glaciation) of this last cold period came to an end about 10,000bp in Europe (Bell & Walker, 1992). The severing of the land bridge with Europe c.9500bp effected Britain's final isolation from the mainland (Yalden, 1999). To all intents and purposes, colonisation by terrestrial animals ceased, therefore the indigenous land animals of the island must have arrived before this event.

THE POTENTIAL INTRODUCTION OF THE LYNX AND OTHER MAMMALS

SWT, along with Scottish National Heritage and the Mammal Society, has approved plans for the reintroduction of the European beaver (*Castor fiber)* to Scotland in 2003 (Kitchener, 2002). Beavers are believed to have last existed in Britain in the fifteenth century (Kitchener & Bonsall, 1997).

The beaver will be the only mammal ever to be actively reintroduced to the UK. It is also the only native rodent species to have become extinct in Britain since the modern fauna became established (Kitehener, 2002). All three of our large carnivores, the wolf (*Canis lupus*), the bear (*Ursus arctos*) and the less widely known Eurasian lynx (*Lynx lynx*) were lost in historic times. The last Scottish wolf is recorded as being killed in the 1740s, three centuries after the beaver's demise but a plan to return wolves to Britain has never come near to the ratification stage. No one can deny that if the beaver is a native of the UK the wolf should be regarded as native also. The situation demonstrates the added cultural and practical complications of reintroduction when the subject is a carnivore. "Nativeness" is by no means the only criterion the species in question can be asked to satisfy.

Wolves, and to some extent bears, have received a great deal of negative publicity through the ages. A lynx reintroduction proposal is less likely to encounter opposition from people whose views are prejudiced by folklore. Compared with the much maligned 'big bad wolf', the lynx is little known and, therefore, a lynx reintroduction proposal is perhaps less likely to encounter opposition before it is even drafted.

The Eurasian Lynx, *Lynx lynx*, belongs to the cat family, Felidae. Felidae is one of the seven

families, which make up the order Carnivora. Also included in this order are the family Ursidae, which includes the brown bear, and the Canidae to which the wolf belongs. There is not complete consensus over the lower level systematics of the lynx. The system used here is in agreement with Council of Europe Action Plan (2000). This is to regard the lynx as a genus within the family Felidae with four species: the Eurasian lynx - *Lynx lynx*, the Bobcat – *L. rufus*, the Canadian Lynx – *L. canadensis* and the Iberian/Spanish Lynx – *L. pardinus*. *L. lynx* is often quoted as having several subspecies - the type occupying Northern Europe being *L. l. lynx* the boreal lynx. Some authorities include the Spanish lynx as one of these subspecies (*L. l. pardinus*) (Kitchener, 1991). Other variations of the classification scheme include regarding *L. pardinus* and *L. lynx* as two of four species in the subgenus *Lynx* of the genus *Felis* (Nowark 1999; Corbet, 1991).

Although the lynx is not listed as endangered by Convention on International Trade in Endangered Species (CITES), the Council of Europe (CoE) maintains it is in need of conservation as a result of population fragmentation. The once pan-European species now exists in several relatively small isolated units. Small populations are generally felt to be less robust as there is a greater likelihood of any stress causing numbers to fall below the viability threshold. The loss of even one local population is unfortunate, but the more drastic consequence of such population structuring is that the species as a whole is at no less risk than the strongest of its isolated constituents. The CoE regarded the lynx situation as serious enough to merit including the species in "the Big Five" (brown bear, grey wolf, Eurasian lynx, Iberian lynx and the wolverine); predatory mammals who form the subject of their initiative aimed at maintaining and restoring the large carnivores of Europe.

It is true that Eurasian lynx become extinct from Scotland over a thousand years before the beaver, but how much importance should be put on this? At what point does the past become recent enough to be relevant? This is a question with no generally accepted answer. The major wildlife agencies do not attempt to answer it. Their primary concern when considering a reintroduction proposal is whether the species in question is more likely to enhance or to disrupt the ecosystem into which it is placed. They follow the International Union of the Conservation of Nature 1995 Guidelines for Re-introduction (Anon, 1995). These call for assurance that: a) there is a suitable source population which will provide animals of appropriate genetic make up without this source itself being compromised, b) an area of adequate size of suitable habitat and food resources is available, c) there are enough qualified staff to undertake the preliminary work, the actual introduction and subsequent monitoring, and d) the costs of all stages have been assessed. Where a species has been lost from an area in the distant past it must be possible to demonstrate using experience gathered within Europe, "that this species has an integral role in the relevant habitat".

Table 1. The Eurasian Lynx, *Lynx lynx*. Morphological and Natural History Variables

Body length	70-130 cm
Height to shoulder	60-75 cm
Weight	12-35kg, average weights: 18.1kg (female), 21.6kg (male)
Dental formula	I 3/3, C1/1, P2/2, M1/1
Coat	Yellow to brown showing seasonal and latitudinal change
Distinctive morphological features	Short tail with black tip, tufted ears, cheek ruffs, wide spreading paws
Life span	17 years in wild
Daily food requirement	1-2.5 kg
Gestation	63-73days
Litter no.	1-4 kittens, usually 2 or 3
Breeding frequency	1 litter per year

THE BIOLOGY AND ECOLOGY OF THE LYNX

The Eurasian Lynx, *Lynx lynx*, is the biggest of the cats in the European region. Its large paws, thick coat and ear tufts are prominent characteristics of the genus Lynx. Table 1 shows other morphological data. At the full extent of its historical range there were populations in western and eastern European countries, much of the former USSR and as far as Iran and China (Alderton, 1993). This remarkably extensive range, one of the widest known for a cat species, spans many types of terrain. Lynx by preference frequent dense cover, but populations live successfully in a variety of habitats. In Europe they are found mainly in deciduous woodland or pine forest. In central Asia, however, they inhabit open, thinly wooded areas. The most northerly extent of their range includes landscapes of tundra and rocky slopes (Jackson, 1996).

Despite obvious morphological adaptation to cold and snowy climates the species is not restricted to high altitudes. In the Carpathians the highest density of the species is found between 700 and 1100 meters, but individuals occur as low as 150 meters. Reports of lynx living at heights of 2000m,

demonstrate the animal's ability to tolerate extreme environments (Bjarvall & Ullstrom, 1986).

An animal able to live successfully in a range of habitats must be capable of behavioural adaptability, as well as being physically robust. The wide geographical range of the lynx is more understandable when one appreciates that a description of the lynx ecology contains more preferences than absolutes. This facilitates the species' wide geographical range Tables 2 and 3 list estimated home ranges in different regions of the overall species' range.

Lynx are classed as nocturnal hunters, although they prefer to rest in the darkest hours and are most active in the hour before nightfall (Jackson, 1996; Burton, 1991). Like other felids, however, they rely on sight and sound when hunting and this practice is ineffective under conditions of poor visibility. Thus, in bad weather the lynx will resort to daytime activity (Kitchener, 1991).

Felids, to which the lynx belongs, are arguably the mammal group most highly adapted to meat eating (Gittleman, 1989). For them, as for all dietary specialists, lifestyle – how and where they live - is dominated by the availability of the appropriate food source in sufficient quantities. The other species in the genus lynx are specialist lagomorph hunters and it is often assumed the Eurasian lynx also relies on hare populations.

Unlike the Canadian lynx (*Lynx canadensis*), which preys almost exclusively on the snowshoe hare throughout the year, there is seasonal and regional variation in the *L. lynx* diet (Kloor, 1999). The Eurasian lynx is the largest of the species and appears to be most successful when feeding on small ungulates (Jackson, 1996). In the Pan-Alpine conservation strategy for the lynx (Adamic et al, 2001), one section states "many items can be found in the lynx diet" and in another the lynx is described as having a "specialist prey requirement". This seems contradictory but not when data on lynx populations over the species' range are brought together.

Lynx specialise to the extent and in a manner that their local habitat allows. Populations take as their staple food the most abundant of a range of prey species. The relative abundance of the local 'favourite' item and the other potential prey species influences the extent to which the favoured item dominates the diet. In Scandinavia red deer (*Cervus elaphus*) form the bulk of the diet. In Switzerland chamois (*Rupicapra rupicapra*) and roe (*Capreolus capreolus*) constitute 85% of all catches. Roe are also the main prey item in the Carpathians. Although in areas where ungulates are scarce lynx are small and in less than peak condition, there is evidence that populations do exist, in north Finland and Siberia for example, where they have to live on a diet almost completely made up of lagomorphs (Jackson, 1996).

A specialized meat eater cannot supplement animal food with non-meat items, like berries and roots, a choice available to omnivorous carnivores such as the bears. A single lynx requires on average 1kg to 2.5kg of meat per day. Survival depends on getting access to a specific resource that requires substantial energy output to obtain. Lynx do this by defending a territory in which they have exclusive hunting rights. The result is a solitary existence. The only association that takes place among adult lynx occurs between males and females during mating periods. Two females never hold the same territory, although the territories of males can overlap.

Male territories are larger than those of females and can encompass parts of several females' territories. The absolute range of both sexes depends greatly on the productivity of the land on which they are residing. Where ungulates are at a high density, ranges are small. As ungulate density decreases ranges have to increase in size for a lynx to have access to sufficient resources. (Breitenmoser, 1998) (Table 2). Two points should be noted about the terminology used in Table 2. Firstly the home area is the area usually around the domicile over which an animal travels in search of food. Secondly, the territory applies to the area within the home range occupied more or less exclusively by an animal or group of animals of the same species and held through overt defence, display or advertisement (Burton, 1979; Bjarvall & Ullstrom, 1986; Kitchener, 1991; Alderton, 1993; Breitenmoser et al., 2000).

Table 2. Ranges of lynx from various types of terrain. (area in km_)

Source	Home Range		Territory (core area)	
	Male	**Female**	**Male**	**Female**
Council of Europe Action Plan 2000	180-27880	98-759		
Council of Europe Action Plan 2001	71-450	45-197		
Wild Cats of the World			200-400	100-150
Mammals of Britain and Europe	Few dozen km, central Europe to 1000km Scandinavia			
Cat Specialist Group IUCN (given as averages)	264 (n=23)	168 (n=64)	150 (n=58)	72 (n=27)

HISTORY OF THE LYNX IN SCOTLAND

There is a dearth of information about former British lynx populations. As with all prehistorically extinct species, period of residence can only be estimated. The oldest fossil find tells us only that the animal existed at this date. The most recent find indicates no more than that the animal was still present at this time.

The palaeontological record for Scotland in the Quaternary is not good. Ice covered the country during much of the Pleistocene and there is a shortage of suitable cave sites. The high acidity of the soil is another factor which mediates against fossilisation (Kitchener & Bonsall, 1997). Only one of the meagre number of lynx fossils found in the UK comes from a Scottish site (Kitchener, 1983; Yalden, 1999). Many British specimens come from sites of 18th and early 19th century excavations so were processed before expertise in recording fossil sequences and handling finds were well developed (Jenkinson, 1983; Kitchener & Bonsall, 1997). Most literature has dated lynx fossil finds by associated species with more complete records, and by the presence of artefacts associated with particular prehistoric cultures (Yalden, 1999).

It has been suggested that lynx were in the UK during the last cold stage (Guggesberg, 1975, quoted in Yalden, 1999). There is little fossil evidence for this. Of the fifteen British finds only four come from sites with pre-Flandrian (<10,000 year ago) sequences. At only one of these did Jenkinson (1983) in his review, regard the occurrence of lynx remains as a genuine indication of the species living contemporaneously with the other creatures present, rather than an artefact of geomorphological mixing or bad handling of recovery operations. Yalden (1999) suggested a postglacial arrival. Roe deer have a reasonable fossil record and some remains can be dated (pollen and carbon 14 dating techniques). They are believed to have entered Britain in the Mesolithic (c.10000-5000bp). It is likely that the lynx would have appeared around this time, obviously before the opening of the English Channel (Yalden, 1999). Sizable lynx populations prior to colonisation by small ruminants are known to have existed only in three areas, all in the northern part of the felid's range (Hedmark, Finland and Ural Mountains) (Breitenmoser et al. 2000).

The latest reliable record, according to Jenkinson (1983), comes from Steely Cave, Yorkshire, where a Mesolithic artefact was found and the pollen sequence matched that of zone VIIa (c. 7000-5000bp).

Subsequently, radiocarbon dating has been performed on a partial skeleton from Reindeer Cave, Inchnadamff, Sutherland, (formerly believed to be no more recent than pollen zone III – c.11,000-10,000 bp.). It was dated at c1880bp, indication of the species' survival in Scotland at least 3200 years after pollen zone VIIa.

The above section on lynx ecology emphasised the animal's ability to adapt its feeding strategy, range and diet depending on its circumstances. The precise nature of the previous British population must be assumed to depend on when it was resident, because the environment was changing over time. The late Devensian saw a rise in temperature above present day levels throughout Europe, but at the very end of the Pleistocene temperature fell once more (11,000-10,000bp). Ever since rapid climatic amelioration terminated the final stacial, (c.10,000bp), European temperatures have oscillated within a range rarely greater than 1-2° above or below present levels. Mid-July temperatures in late glacial were 7-9°. Mesolithic average July temperature was 15° (Bell and Walker, 1992).

The warming considerably altered the British landscape through its long-term effect on the vegetation. Pollen records show a trend of increasing forestation through most of the Mesolithic (c10,000-5000bp) (Price, 1983). The woodland matured and its constituents altered partly a result of adapting to fluctuating precipitation levels, which remained dynamic despite temperature stability.

Table 3. Densities of lynx in different habitats.

Area	Density (individuals/100km)
Poland	1.9-3.2
Switzerland, Jura mountains	0.94
Switzerland, North Alps	1.2
Switzerland, central Alps	1.43
South Norway	1
Sweden	0.34-0.74
Bialowieza	10-19
Russia	< 4

The modern habitat most similar to the British lowlands in the first half of the Flandrean is thought to be that of the Bialowieza forest, Poland (Yalden, 1999). Figures show Bialowieza to have the highest densities of lynx so far recorded (Cat Specialist Group web site). Table 3 shows how density varies from area to area. This is likely to be an indication of near optimum conditions. The 580km^2 forest provides a habitat of wide rivers, reed beds and lagoons. The rich landscape is able to support about 3700 red deer and 2700 roe, ample prey for the 19 lynx and around equal numbers of wolves believed to reside in Bialowieza (Yalden, 1999). Yalden (1999) calculated that at this density the whole of the UK (230,367km^2) could have

supported 7543 lynx. If he is correct Mesolithic British lynx were certainly not dwindling.

A British lynx extinction during the Mesolithic in Pollen zone VIIa does not have an obvious cause. Climate change alone does not seem a likely explanation (Yalden, 1999). The range of the Eurasian lynx spans an area over which the geographical temperature range is greater than the temporal variation Britain is thought to have experienced during the Mesolithic. It is likely the species would have had the capacity to cope with the altering temperature and weather conditions (Kitchener & Bonsall, 1997; Yalden, 1999).

The much more recent history of lynx decline on the continent gives clues as to the factors which are likely to undermine the species. During the eighteenth and nineteenth centuries deforestation to make way for an expanding agricultural industry drastically reduced the amount of natural woodland on the continent of Europe. The increasing human population overexploited what remained. This resulted in severe degradation of the lynx's preferred habitat. Since the lynx uses an ambush hunting technique, the percentage of attacks that are successful is highest in areas of dense forest (Breitenmoser, 1998). Deforestation has also directly influenced the contemporary fall in wild ungulates numbers. (Breitenmoser, 2000; Breitenmoser, 1998) Hungry predatory animals resorted to supplementing their diet with ungulates from the increasing domestic herds, thus farmers were added to gamekeepers and fur trappers as direct persecutors of the lynx.

Drastic reduction of woodland took place in Britain centuries before it became a major issue on the European mainland. Jenkinson's review reports of "woodland clearance by human groups" beginning at the end of the Mesolithic (Jenkinson, 1983). This substantiates his belief of a Mesolithic extinction of the lynx. However, Bell & Walker, (1992) while agreeing that clearance of woodland did take place in the late stages of the Mesolithic stated that the effect of hunter gathering societies on the landscape is limited to a local level.

At the very end of the Mesolithic the lifestyle of humans in Britain changed fairly abruptly from hunter to farmer. They then began to have a significant impact on the landscape (Bell & Walker, 1992). It is plasticity of lifestyle which allows the lynx to survive in areas less than ideally suited to its ecology. If the productivity of the habitat declines, the territory size of each lynx must increase if the animals are to survive. This will cause the population density to fall and eventually the population will become extinct. In prehistoric Britain the lynx would have been put under additional pressure as those animals on British soil turned into island populations, limiting the area available for expansion. Yalden (1999) suggests that the strain, when combined with hunting pressure, could have led to the lynx's disappearance from Britain. Thus it appears the survival of British lynx into the Neolithic is more understandable than its extinction before the end of the Mesolithic.

The latest data on the Inchmadamph skeleton suggest the lynx's time of residence could have extended into 'historic' times. This discovery has important implications for the debate on the wisdom of lynx reintroduction to Scotland. The time between the Neolithic and the Roman occupation was when the characteristic fauna of modern Britain developed. By the time of the Roman invasion, human clearance had transformed the island into what was essentially an agricultural landscape (Yalden, 1999).

DISCUSSION

In the introduction to this article I have stated my view of the requirements for a successful reintroduction. I then reviewed the biology and ecology of the lynx, and described the history of the lynx in Scotland. I now discuss the potential introduction of lynx to Scotland in more detail, and evaluate the extent to which founding a lynx population in Scotland fulfils the requirements and the Council of Europe's Action plan. I have divided the discussion into two parts – feasibility of reintroduction, and benefits of reintroduction.

Feasibility

Had climate change played a major role in the downfall of the British lynx population, reintroduction would be inappropriate and, most likely, impossible. The latest evidence, however, suggests lynx survived in Scotland into Roman times. This increases the legitimacy of arguments for the species' reintroduction to Northern Scotland because it implies that maintaining a lynx population in modern Britain could be ecologically viable and there could be a niche in our ecosystem for these cats. Something other than unsuitable natural habitat must therefore have been responsible for the loss of the species from Britain. One recommendation of Council of Europe's 2000 action plan is that "The historical decline of the lynx should be analysed, the threats to the population identified and measures to remove limiting factors taken." (Breitenmoser, 2000). In the case of the British lynx this would be a more complex task, since the period under investigation would be the ancient rather than the recent past. The century, and therefore the environmental conditions, in which the lynx perished are rather uncertain. Investigation of the history of the lynx in Britain is a crucial part of piecing together the circumstances of its demise, but one cannot simply extrapolate from this to the steps required to allow its return. Examination of the way in which modern day lynx are faring in various types of habitats and the success or otherwise of management and conservation can provide some information.

The European *Lynx lynx* population reached an all time low on the continent in the 1950s and '60s. At this time it was extinct from south, west and northern countries, remaining only in Fennoscandia (Norway, Sweden, Finland), the Eastern

Carpathians and White Russia (present day Belarus), (Bjarvall & Ullstrom, 1986). Lynx reintroduction programmes began in the 1970s but conditions had begun to recover before this (Breitenmoser, 1998). By the end of the nineteenth century authorities had started to appreciate the environmental importance of forest regeneration (Breitenmoser, 1998). As conditions improved ungulate numbers recovered. The lynx was able to recolonise parts of its former range. Recovery was aided in many countries by the introduction of legal protection (Breitenmoser et al. 2000).

Alderton (1993) noted that only three of nine reintroductions appeared to have been viable in the long term, two Swiss projects (Dinaric population, Alpine population) and the Slovenian (Carpathians) programme Successful introductions have been in areas of dense forest and high ungulate density. Of the ten recognised European populations only two do not cross national boundaries. Pan-European collaboration on the regeneration of Europe's carnivores means lynx can move freely over vast tracts of land. The forests of Britain were decimated long before their importance was appreciated and earlier than those in most mainland European countries. Serious attempts at reversal began later. All the evidence suggests that successful reintroduction requires forestation or other suitable cover over a sufficient area and, certainly in the early stages, legal protection and population monitoring.

Even if Britain were to sign up to the Action Plan of the Council of Europe a UK population would remain insular. The importance of this is made apparent by the knowledge that some small countries in mainland Europe do not have sufficient area to support an independent population. In addition, where reintroduction has been tried in areas where natural recolonisation is not a possibility, the amount of work required is even greater and success is even less certain (Breitenmoser et al., 2000).

Rural Britain is does not lack areas where the concentration of deer should be adequate to support a reasonable number of lynx (Yalden, 1999). Suitably sized sites of dense, upland forest are more limited. Scotland is better endowed with appropriate expanses than England.

More effort would have to be put into reforestation, specifically expanding existing woodland sites, if a population of lynx in Scotland was to have a chance of becoming ecologically feasible.

The next issue is how well such a population could coexist with the resident Scottish biota. Of particular importance is whether the introduction of a large predator would lead to competition with the present Scottish carnivores, and how our deer populations would respond to a serious wild hunter.

The member of our fauna most closely related to the lynx is the Scottish wild cat *(Felis silvestris grampia).* It might be expected therefore that wild cats would be the indigenous carnivores put at greatest risk by a lynx return. Wildcats are protected under a schedule of the Wildlife and Countryside Act 1981. Any venture that could threaten them is likely to meet with strong opposition from many conservationists. Although wildcats inhabit most of the same general parts of the continent as lynx, they are by and large at lower altitudes (<500m) and catch only smaller prey items (Corbet and Harris, 1991). None of the literature cited here on lynx reintroduction mentions significant competition between the two species. It seems therefore, the Scottish wildcat and the lynx could coexist as part of a carnivore guild, provided that deer did not become scarce.

There is no consensus on either the extent or the nature of the lynx's effect on wild ungulates. In a review of the lynx in Switzerland, Breitenmoser (1998) stated that on fairly barren territory lynx home ranges are large and not a major factor in determining the number of small ungulates: where prey is plentiful lynx hunting in a concentrated area can significantly shrink populations of deer at a local level. Other reports, cited in the Council of Europe's Action Plan for the Lynx, (2000), suggested that it is at the margins of ungulate ranges where population is least dense that lynx predation most greatly disrupts ungulates. It appears that the results of predation are heavily dependent on the structure of the ungulate population, but the relationship is not straightforward and other factors are also involved (Breitenmoser et al., 2000).

The human species is itself a member of an area's biota. The manner in which the people of Britain would receive the lynx is hard to determine. Ultimately, it could tip the balance between the success or failure of the venture. On the continent the anthropogenic difficulties faced by large predators are most acute where they are reintroduced into areas from which they have long been absent. The largest difficulties are where sheep are left to graze unattended (Breitenmoser, 1998). This is the practice in Britain.

Presenting humans as 'just' another member of the biota is misleading. Apart from the magnitude of our influence, the most important feature is that our perception of the effect another creature has on us is as influential as the effect itself. Definite evidence that lynx in Scotland would threaten the welfare or economic interests of the Scottish people is scarce: the threat which human hostility could pose to the successful reintroduction of the species to Scotland is very real.

The first stage of any reintroduction must be a feasibility study (Breitenmoser et al., 2000). Certain conditions are made apparent by the above. A lynx population would have to be confined to a designated area which must contain sufficient resources to sustain the population without the area being compromised in any way. The site would have to be located so that conflict between people and the lynx was minimised and road casualty, a major cause of death of reintroduced lynx,

(Jackson, 1996; Council of Europe, 2000) avoided as far as possible.

If this information can be simplified into a set of fundamental requirements computer modelling techniques can be used to provide information which helps in the planning the venture. Geographic Information System (GIS) is an analysis technique which can determine the number of sites, in designated size categories, available in the study area (Scotland) and how many animals each could support. If supplied with the necessary biological variables PVA (population viability analysis) programmes allow an estimation of the likely number of release animals required if there is to be reasonable certainty of the population surviving on average for a specified length of time A 95% chance of survival for at least 50 years was the level used by Leaper et al. (1999).

The lynx is not an endangered species but, as has been mentioned, many populations in Europe are felt to be vulnerable. The source animals for the reintroduction of a British population would need to be taken from an area where density was reasonable and not in decline. With reintroduction of a long absent species there is not, as there is with population supplementation programmes, the danger of contaminating an indigenous subspecies with another subspecies. However, it would be judicious to use source animals from an area with similar ecology to the terrain being repopulated.

Much depends on the value organisations such as SWT would place on returning the lynx to Britain and how it would rate in importance relative to their other commitments.

Benefits

A primary purpose of the CoE in reintroducing lynx to places they formerly inhabited is the establishment of viable populations or sub-populations of viable metapopulations. Returning the lynx in Scotland would have very little impact on the success or failure of the redevelopment of a pan-European population. So such an action would be of negligible benefit to the species as a whole

If one's only concern were the welfare of the species, returning it to Scotland would be a waste of human and financial resources. Given the potential disruption to the source population, it could be seen as counterproductive. As a component of an action plan with the aim of improving the host ecosystem, however, it could be extremely useful.

The pattern in Britain, common to most areas of significant human colonisation, has been to increase ungulates numbers, which are a source of food and a focus of sport. The large carnivores, potential competitors for game, are persecuted. The natural equilibrium is destroyed and not allowed to redevelop. The red deer population now numbers c.300,000. Their browsing causes economic and environmental damage, and the food requirement of the increasing population is beyond the capacity of the available habitat (SNH web site). Insufficient nutrition can compromise the health of all age groups in the herds. Culling measures have so far been insufficient to halt the escalation. The presence of lynx is not suggested as a complete solution, but reintroduction of a natural predator is a measure so far untried, which could assist deer regulation.

Lynx have had much less effect on sheep populations than either bears or wolves in Europe and they never attack cattle (Breitenmoser, 1998). They are the most likely of the three to remain in remote areas and thus least likely to inhabit areas close to human settlement. On the continent they are not even perceived as 'man eaters', which both the bear and the wolf often are (Yalden, 1999).

A proposal has been put forward for setting up a lynx population on the Island of Rum (Nevard & Penfold, 1978). Manufacturing an artificial community on an island without requiring attitudes to alter would not greatly broaden our understanding of the changes that would be required to make the countryside of the Scottish mainland suitable for a functional lynx population.

Large predators are "keystone species'. They are the top of the food chain so their survival depends on the lower level of the chain functioning well. Investigating the viability of establishing a modern day British lynx population, even if the conclusion was not in the affirmative, would be a worthwhile exercise. The presence of a healthy lynx population is indicative of a healthy ecosystem. Aiming to create 'a lynx friendly environment', however slight the chances of complete success, would benefit a substantial proportion of the resident Scottish biota.

CONCLUSION

The lynx would not enter the minds of most British people should they ever be asked to name the creatures of the country's wilder past. Yet the Eurasian lynx is indeed native to Britain, in the sense that the species colonised this island independently during the Mesolithic, before Britain became separated from Europe (c9500bp). Recent work done on the Inchmadamph skeleton dated it at c1880bp and suggests the species survived in Scotland into historic times – post the Roman invasion of Scotland (c.43 bp). With this knowledge it seems more likely that the reintroduction of the lynx to Scotland would conform to IUCN criteria designed to ensure projects do not undermine donor populations or host ecosystems.

Its ability to hunt in different ways, combined with a tough physique, allowed the lynx to become one of the most widespread of the Felidae. These same characteristics make it quite possible that the species could find food and survive in the Scottish climate. There is no resident native British carnivore that would be at risk of intense competition for resources with the lynx. Even wild cats and foxes, the largest of our present carnivores, are much smaller and foxes are considerably more inclined to be omnivorous.

Interested parties are not in agreement over whether lynx are likely to prey intensively on livestock. Evidence does suggest that of the three possible candidates for reintroduction of a large carnivore to Britain, wolf, bear and lynx, the lynx is the least liable to cause a serious problems to farmers.

The conclusion that lynx reintroduction is theoretically feasible is not in itself justification for undertaking a scheme. A major objective of CoE lynx initiatives is the establishment of populations that contribute to the stability of metapopulations. Returning the lynx to Scotland would not significantly further this aim. It would create yet another discrete population, and in this case, there would not be the possibility of eventual amalgamation with populations in neighbouring countries.

Unlike the projects on the continent, the primary benefit of restoring a Scottish lynx would be for the existing fauna of the host country rather than for the lynx itself. We live in a country where forests and wild areas were removed to make way for agriculture. The wild animals have all been affected to a greater or lesser extent by habitat destruction. In addition game species have been encouraged, resulting in great rises in numbers of individuals. Meanwhile predators have suffered persecution and the outcome is the disappearance of all large carnivores. An investigation into the adjustments in land management necessary to enable a reintroduced population of lynx would highlight problems that directly and indirectly compromise many of our indigenous species.

The first is whether sufficient suitable habitat exists, or could be created, in Scotland to sustain a viable population. The second issue is anthropogenic difficulties, such as the widespread perception that the introduction of a large carnivore will inevitably cause major disruption.

With the present climate being relatively favourable to the general idea of reintroduction it would seem an appropriate time to investigate seriously the return of the lynx to Scotland. Bearing in mind the potential problems mentioned above, however, it is crucial that a feasibility study puts emphasis on determining how many lynx could be expected to live in the country, and whether it would be possible for British people to coexist with a major predator population without the much feared side effects.

REFERENCES

Adamic, M., Breitenmoser-Wursten, C., Breitenmoser, U., Fasel, M., Huber, T., Kaczensky, P., Koren, I., Molinari, P., Molinari-Jobin, A., Rotelli, L., Stahl, P., Stanisa, M., Vandel, J. and Wolfl, M. 2001. Pan-Alpine Conservation Strategy for the Lynx. *Convention on the Conservation of European Wildlife and Natural Habitats*. Council of Europe, Strasbourg.

Anon. 1979. Convention on the conservation of European Wildlife and natural habitats. 19.IX.1979, *European Treaty Series/104*, Bern.

Alderton, D. 1993. *Wild Cats of the World*. Blandford, London.

Bell, M. and Walker, M.J.C. 1992. *Late Quaternary Environmental Change: Physical and Human Perspectives*. Longman, Harlow.

Bjarvall, A and Ullstrom, S. 1986. *The Mammals of Britain and Europe*. Croom Helm, London.

Breitenmoser, U. 1998. Large predators in the Alps: the fall and rise of man's competitors. *Biological Conservation* 83, 279-289.

Breitenmoser, U., Breitenmoser-Wursten, Ch., Okarma, H., Kaphegyi, T., Kaphegyi-Wallmann, U. and Muller, U.M. 2000. Action plan for the conservation of the Eurasian Lynx in Europe. *Nature and Environment Series* 112: 1-69, Strasbourg, Council of Europe.

Burton, R. 1979. *Carnivores of Europe*. Cox & Wyman, London.

Corbet, G.B. 1984. *The Mammals of the Palaearctic region: A Taxonomic Review*. British Museum, Natural History, London.

Corbet, G.B. and Harris, S. 1991. *The Handbook of British Mammals* third edition. Blackwell Scientific Publications, London.

Gittleman, J.L. 1989. *Carnivore Behaviour, Ecology and Evolution*. Chapman & Hall, London.

Jackson, P. and Nowell, K., 1996. Wild Cats: a status survey and conservation action plan. IUCN, Gland, Switzerland.

Jenkinson, R.D.S. 1983. The recent history of northern lynx, (*Lynx lynx, Linne*) in the British Isles. *Quaternary Newsletter* 41, 1-7.

Kitchener, A. 1991. *The Natural History of the Wild Cats*. Christopher Helm, London.

Kitchener, A.C. 2002. Alien mammals: wreaking havoc or missing the boat? *Glasgow Naturalist*, 23, Supplement.

Kitchener, A.C. and Bonsall, C. 1997. AMS radiocarbon dates for some extinct Scottish mammals. *Quaternary Newsletter* 83, 1-11.

Kloor, K. 1999. Lynx and biologists try to recover after a disastrous start. *Science* 285, 320-321.

Leaper, R., Massei, G., Gorman, M.L. and Aspinall, R. 1999. The feasibility of reintroducing Wild Boar (*Sus scrofa*) to Scotland. *Mammal Review* 29, 239-259.

Nevard, T.D. and Penfold, J.B., 1978. Wildlife conservation in Britain: an unsatisfactory demand. *Biological Conservation* 14, 25-44.

Nowark, R.M. 1999. *Mammals of the World 6th Edition (Vol I)*. Baltimore and John Hopkins University Press, London.

Price, J.R., 1983. *Scotland's Environment during the Last 30,000 years*. Scottish Academic Press, Edinburgh.

Reintroduction Specialist Group. 1995. IUCN/SSC Guidelines for Re-Introductions. IUCN Species Survival Commission, Gland, Switzerland..

Scottish Wildlife Trust, 2000. *Policy on Introductions, Re-introductions and Translocation of Species*. Scottish Wildlife Trust, Edinburgh.

Yalden, D.W. 1999. *The History of British Mammals*. T & A.D. Poyser, London.

Web Site

SNH web site: http://www.snh.org.uk/